

# **Lake Eucha Basin SWAT 2000 Model Simulations Using New Row Crop/Small Grains Soil Test Data**

Submitted to:  
Tulsa Metropolitan Utility Authority

Authored by:  
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## Justification

Additional SWAT modeling was performed using data that were not known to exist at the time of the *Modeling the Lake Eucha Basin Using SWAT 2000* (August 9, 2002) report. We were told by Cooperative Extension Service and Conservation District representatives that green bean was the primary row crop in the basin. We were also told by Cooperative Extension Service representatives that neither Oklahoma or Arkansas soil testing laboratories kept specific records on soil test phosphorus (STP) for green beans. We had been told that both labs included green beans into their "Garden" category, which would have overstated the row crop STP level. Thus, the assumption was used that row crop STP was the same as pasture STP. Recently, as part of an unrelated project in the same geographic area, we discovered that there were STP data for green beans in Benton County, Arkansas. Utilizing this actual STP row crop data the model was rerun.

County level soil test data for row crop/small grains fields were obtained for Benton and Delaware counties and incorporated into the SWAT model. Data for Benton county were taken from the University of Arkansas Soil Testing and Research Laboratory website (<http://www.uark.edu/depts/soiltest>). County and crop codes required to utilize these data were obtained from Nathan Slayton (Director of Soil Testing, University of Arkansas Soil Testing and Research Laboratory). These data were corrected for differences in laboratory methods, yielding a Mehlich III STP value of 212 lb/acre for Benton county row crop/small grains. Data for Delaware county were compiled by the Oklahoma State Soil, Water & Forage Analytical Laboratory at our request. An average of 155 lb/acre was calculated for row crops/small grains in Delaware county. These county averages were weighted by the number of observations in each county to produce a weighted average of 188 lb/acre. These soil test data are summarized in Tables 1 and 2.

In the August 9, 2002 report, a single slope was derived for urban and row crop/small grains areas in each subbasin. Further investigation indicated that these categories have different slopes, thus they were treated separately in these new SWAT simulations. We derived slope for row crop/small grains only from fields larger than 10 acres. The average slope for row crop areas was reduced from 3.8% in the August 9, 2002 report to 2.5%. In addition, slope for urban areas changed from 3.8% to 4.8% in the new model simulations.

## Calibration

A new calibration was required once these new data were included in the SWAT model. The hydrologic calibration was still acceptable; some stations even showed some improvement over the August 9, 2002 report. Relative errors in total flow for the period 8-98 to 3-02 are -1.5% at Spavinaw Creek, -0.1% at Beaty Creek, and -0.5% at the Black Hollow stream gage. The following modifications were made to calibrate the new SWAT model:

P Factor for Forest set to 0.9, all other land covers set to 0.3  
BIOMIN (Minimum Dry Biomass for Grazing (kg/ha)) for Well Managed Pastures = 1200  
BIOMIN (Minimum Dry Biomass for Grazing (kg/ha)) for Poorly Managed Pastures = 800  
PPERCO (Phosphorus Percolation Coefficient) = 4  
PHOSKD (Phosphorus Soil Partitioning Coefficient) = 550  
PSP (Phosphorus Sorption Coefficient)= 0.40

## Load Source Identification and Estimation

As in the August 9, 2002 report, a series of simulations were performed to determine the source of the current nutrient load to Lake Eucha (Tables 3-7). STP for forested areas and nutrient calibration remained constant in all scenarios. The sources of the current load were isolated as follows:

- Load due to the application of poultry litter to pastures and row crop was estimated as the difference in the model with the current application rate and no litter application.
- The contribution of increased STP over background was estimated as the difference between the calibrated model at current STP and 30 lb/acre STP.
- The effect of grazing was estimated as the difference between (1) the model with no litter, low STP, and grazing at the current rate and (2) the model with low STP, no pasture fertilization, and no grazing.
- Loading due to land cover changes were estimated as the difference between (1) the current model with an STP of 30, no cattle, and no pasture fertilization and (2) all forested background conditions.

**Table 1** Soil test phosphorus observations for row crops and small grains in Delaware county, Oklahoma. Source: Oklahoma State Soil, Water & Forage Analytical Laboratory 1994-2001.

Crop	Samples	Average
Corn	2	360
Grain Sorghum	4	91
Oats	2	662
Small Grains for Grazing	9	83
Sorghum Ensilage	1	191
Sorghum-Sudan Hay	5	237
Soybeans	17	142
Wheat	30	134
Wheat Silage	1	71
Average	72	154.6

**Table 2** Soil test phosphorus observations for row crops and small grains in Benton county, Arkansas. Source: University of Arkansas Soil Testing and Research Laboratory 1999-2001.

Crop	Samples	Average
BEANS - SNAP (ROWS LESS THAN 3 FT. APART AND IRRIGATED)	4	196
BEANS - SNAP (ROWS MORE THAN 3 FT. APART, NOT IRRIGATED OR IRR.)	23	144
CORN FOR GRAIN	2	168
CORN FOR SILAGE NON-IRRIGATED, HIGH YIELD POTENTIAL	4	193
CORN FOR SILAGE NON-IRRIGATED, MEDIUM YIELD POTENTIAL	5	225
OATS FOR GRAZING	3	359
RYE FOR GRAZING	6	229
RYEGRASS	17	187
SMALL GRAIN/RYEGRASS/CLOVER	11	107
SORGHUM X SUDAN	8	458
SOYBEANS ALONE - NON-IRRIGATED	10	123
SUDANGRASS	1	261
WHEAT FOR GRAIN	6	208
Average	100	195.4

**Table 3** Observed and SWAT predicted average nonpoint source annual nutrient load at City of Tulsa water quality stations for the period January 1998 to March 2002. City of Decatur point source loading removed from relevant stations assuming the estimated load is 90% soluble and no soluble P is converted to particulate forms by in-stream processes before reaching EUC08. High flow sample is defined as three times the average flow; a maximum of two high flow samples are counted for each day. Relative weight is based on the number of high flow samples and the drainage area at each station.

Station	AREA km <sup>2</sup>	High Flow Total P Samples	Relative Weight	Observed Total P kg/yr	Predicted Total P kg/yr	Relative Error Total P	Observed Soluble P kg/yr	Predicted Soluble P kg/yr	Relative Error Soluble P
EUC04	20.9	4	0.01	166	278	-68%	11	140	-1158%
EUC05	87.1	4	0.03	2489	4045	-63%	979	1323	-35%
EUC06	153.0	28	0.31	8461	8243	3%	3650	3673	-1%
EUC07	50.6	2	0.01	1161	795	32%	159	280	-76%
EUC08	517.6	16	0.61	23341	22936	2%	3918	12388	-216%
EUC11	65.9	4	0.02	3982	3431	14%	1327	1766	-33%
EUC12	64.3	2	0.01	813	1247	-53%	498	425	15%
SPA06	15.6	12	0.01	114	110	4%	41	23	44%
Average Weighted Relative Error						0%			-140%

**Table 4** Phosphorus load allocation by land cover for the Lake Eucha/Spavinaw basin. Derived from SWAT model predictions for the period 1/1998 to 12/2001. Assumes point source is 90% soluble and is not modified by in-stream processes.

Land Cover	Area (%)	Total P	Soluble P
Urban	1.3%	1.0%	1.1%
Forest	51.3%	7.1%	3.7%
Hay	13.3%	9.8%	13.4%
Poorly Managed Pasture	6.5%	22.6%	11.5%
Range	0.1%	0.02%	0.02%
Well Maintained Pasture	23.1%	23.2%	32.7%
Row Crop/Small Grains	2.6%	13.2%	1.6%
Point Source	NA	23.1%	35.9%

**Table 5** Phosphorus load by land cover for several scenarios. Derived from SWAT model prediction for the period 1/1998 to 12/2001. Assumes point source is 90% soluble and is not modified by in-stream processes. STP indicates Soil Test Phosphorus.

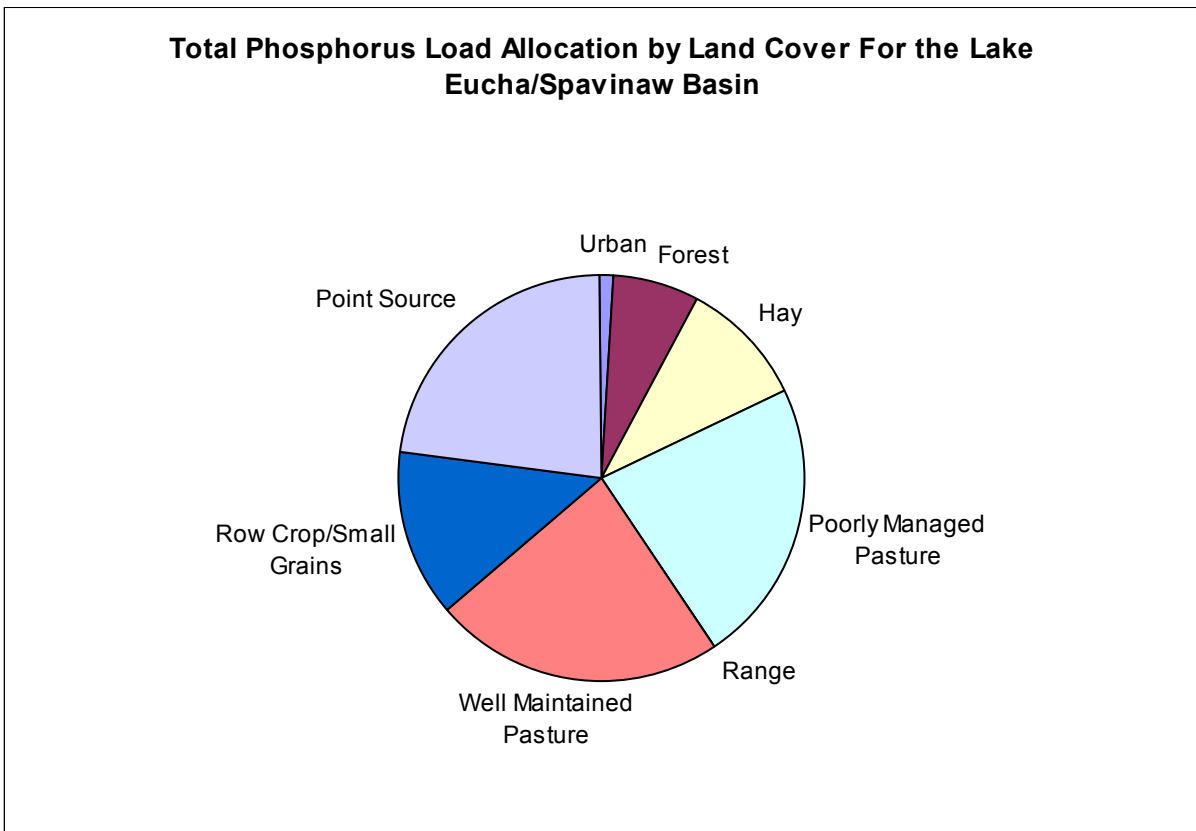
Scenario	Urban	Forest	Hay	Poorly Managed Pasture	Range	Well Maintaine d Pasture	Row Crop	Basin Total	All Pastures	Row Crop
Total P Kg/yr										
Calibrated	521	3,553	4,894	11,280	11	11,575	6598	38,432	27,749	6,598
No Litter	521	3,553	1,003	6,398	11	4,521	5893	21,900	11,922	5,893
Low STP	311	3,553	4,177	9,343	4	10,340	2507	30,236	23,861	2,507
Low STP No Litter	311	3,553	603	4,067	4	3,162	2002	13,702	7,832	2,002
Low STP no Litter no Cattle	311	3,553	955	475	4	1,247	1987	8,532	2,677	1,987
Point Source								11,530		
Background	106	3,553	571	292	7	1,094	91	5,714	1,957	91
Soluble P Kg/yr										
Calibrated	328	1,051	3,853	3,314	6	9,416	457	18,426	16,584	457
No Litter	328	1,051	490	1,372	6	3,094	382	6,724	4,956	382
Low STP	197	1,051	3,340	2,874	1	8,524	86	16,073	14,737	86
Low STP No Litter	197	1,051	263	979	1	2,265	27	4,784	3,507	27
Low STP no Litter no Cattle	197	1,051	785	380	1	1,022	24	3,462	2,187	24
Point Source 90% Sol								10,337		
Background	45	1,051	263	122	3	509	50	2,043	894	50

**Table 6** Phosphorus load source by land cover for the Lake Eucha/Spavinaw basin. Derived from SWAT model predictions for the period 1/1998 to 12/2001. Assumes point source is 90% soluble and is not modified by in-stream processes. STP indicates Soil Test Phosphorus.

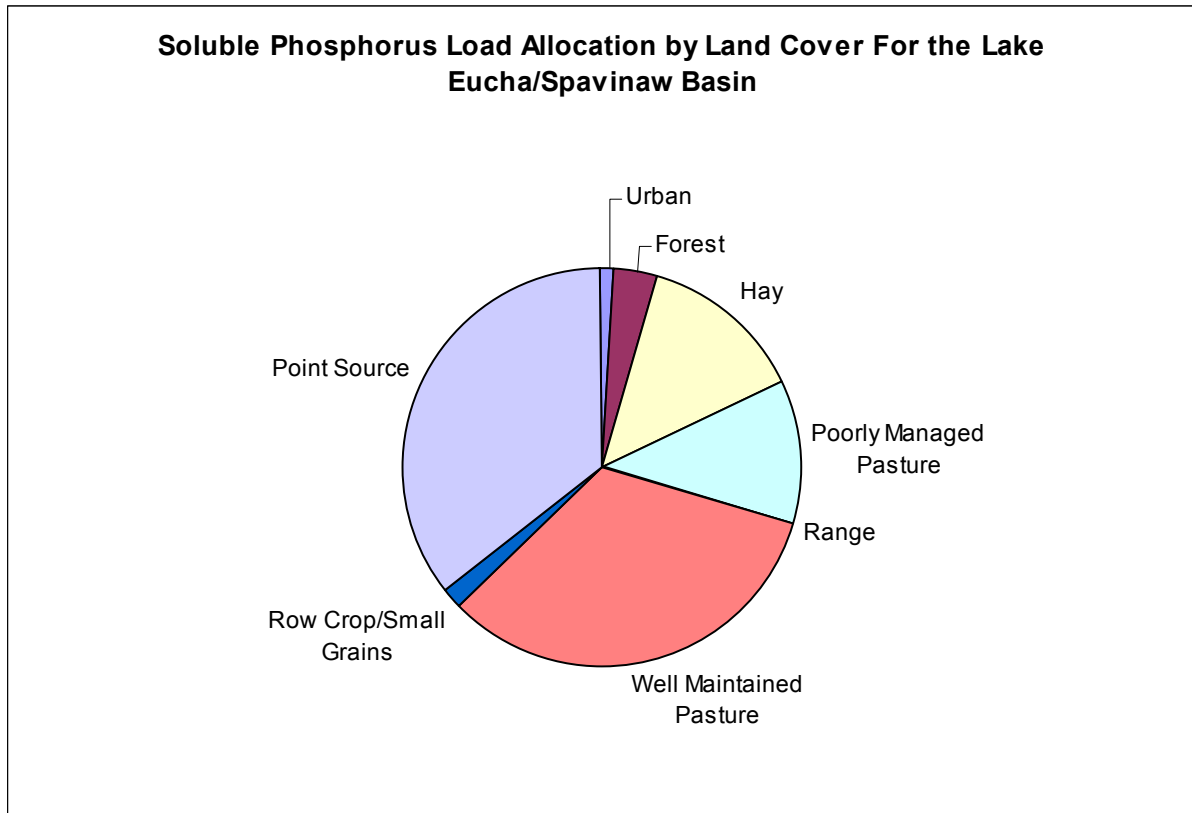
Source	Total P			Soluble P		
	Total	Pastures	Rowcrop	Total	Pastures	Rowcrop
Due to litter	16532	15827	705	11702	11628	74
Due to STP increase	8196	3888	4091	2352	1846	371
Due to STP/litter interaction	2	203	-200	-413	-397	-16
Due to land cover change	2818	720	1896	1418	1294	-26
Due grazing	5170	5155	15	1323	1319	3
Background conditions	5714	1957	91	2043	894	50
Decatur point source	11530	0	0	10337	0	0

**Table 7** SWAT predicted phosphorus load by source for the Lake Eucha Basin by land cover. Assumes point source is 90% soluble and is not modified by in-stream processes. STP indicates Soil Test Phosphorus.

Source	Total P			Soluble P		
	Total	Pastures	Rowcrop	Total	Pastures	Rowcrop
Due to litter	33.1%	57.0%	10.7%	40.7%	70.1%	16.3%
Due to STP increase	16.4%	14.0%	62.0%	8.2%	11.1%	81.3%
Due to STP/litter interaction	0.0%	0.7%	-3.0%	-1.4%	-2.4%	-3.6%
Due to land cover change	5.6%	2.6%	28.7%	4.9%	7.8%	-5.6%
Due grazing	10.3%	18.6%	0.2%	4.6%	8.0%	0.7%
Background conditions	11.4%	7.1%	1.4%	7.1%	5.4%	10.9%
Decatur point source	23.1%	N/A	N/A	35.9%	N/A	N/A

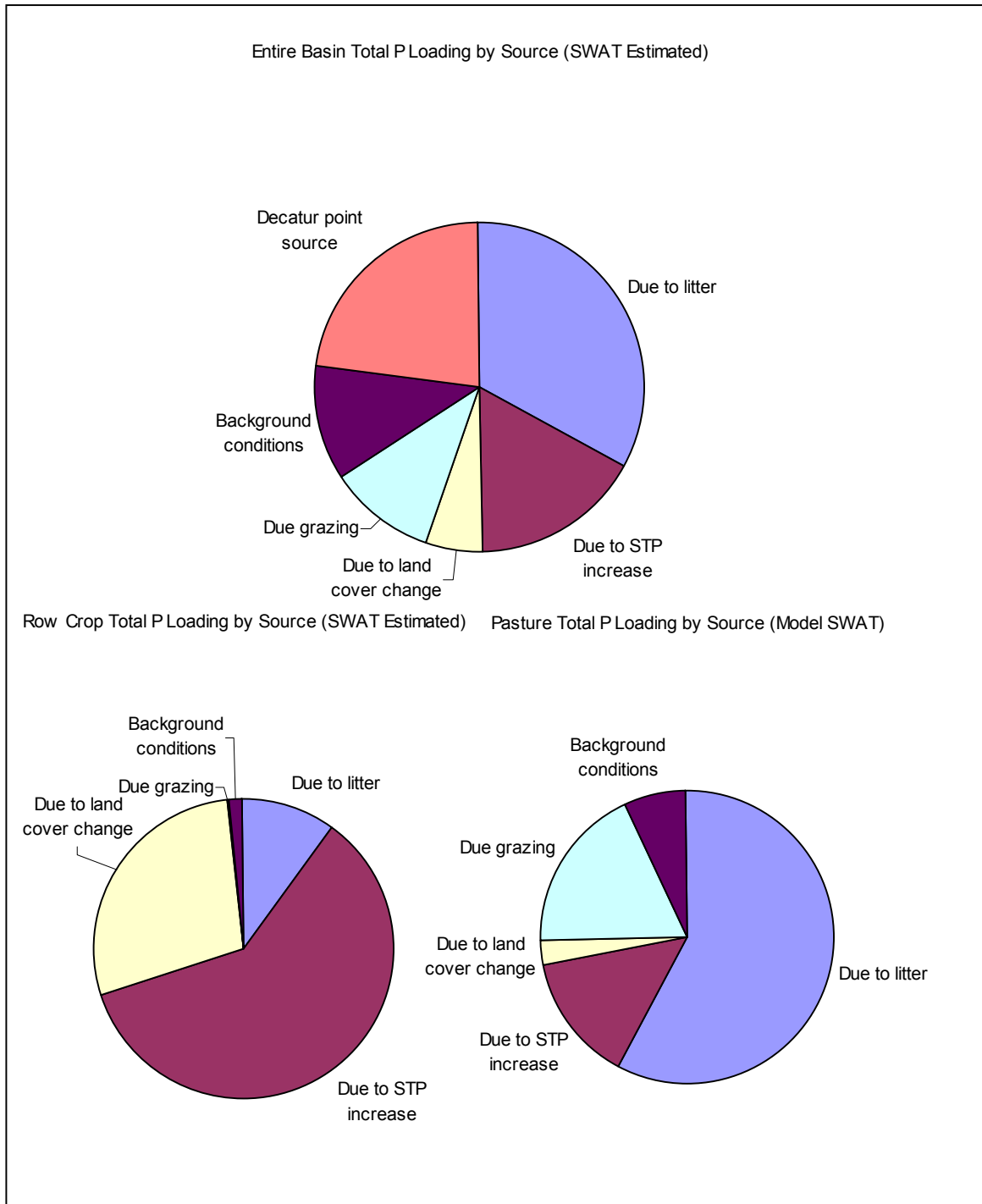


**Figure 1** Total phosphorus load allocation by land cover for the Lake Eucha/Spavinaw basin. Derived from SWAT model predictions for the period 1/1998 to 12/2001.



**Figure 2** Load allocation of soluble phosphorus by land cover. Derived from SWAT model data for the period 1/1998 to 12/2001.





**Figure 3** Total phosphorus load by source for the Lake Eucha/Spavinaw basin and for pasture and row crop/small grains. Derived from SWAT model data for the period 1/1998 to 12/2001. STP/litter interaction is distributed across litter and Soil Test Phosphorus (STP).

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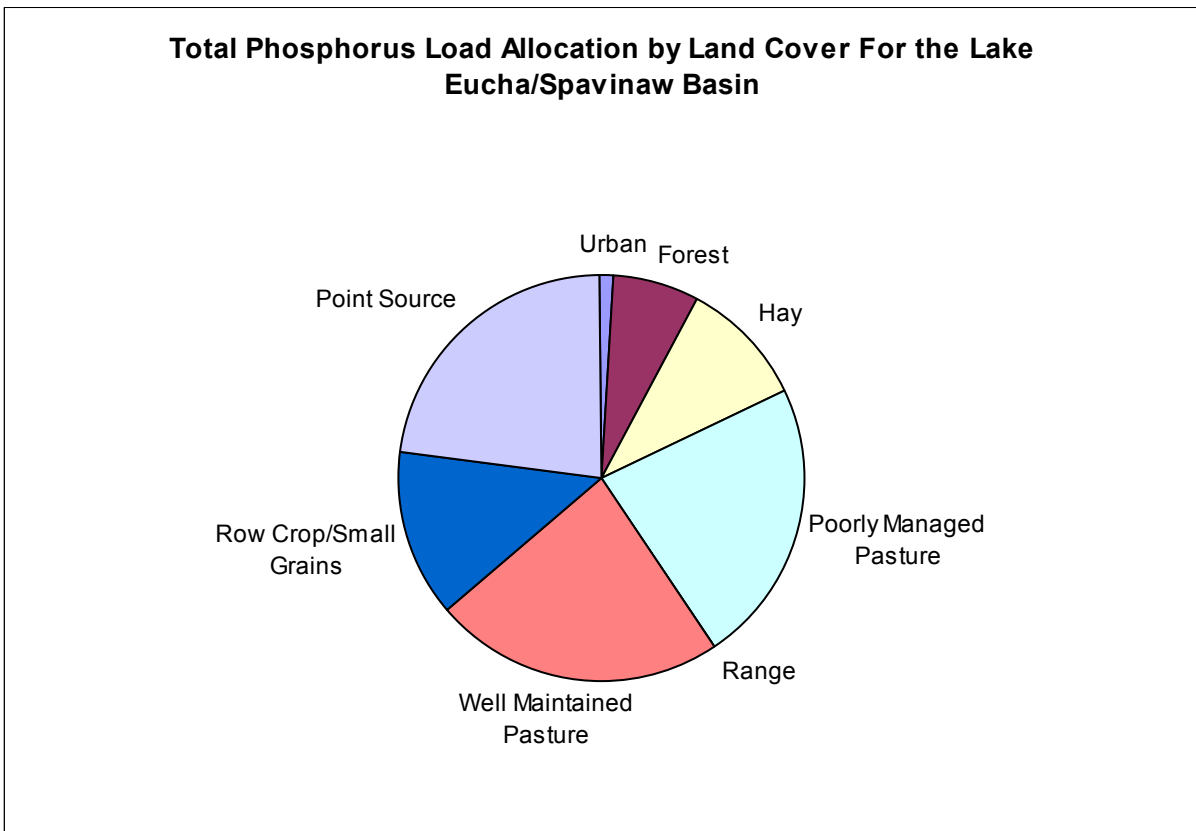
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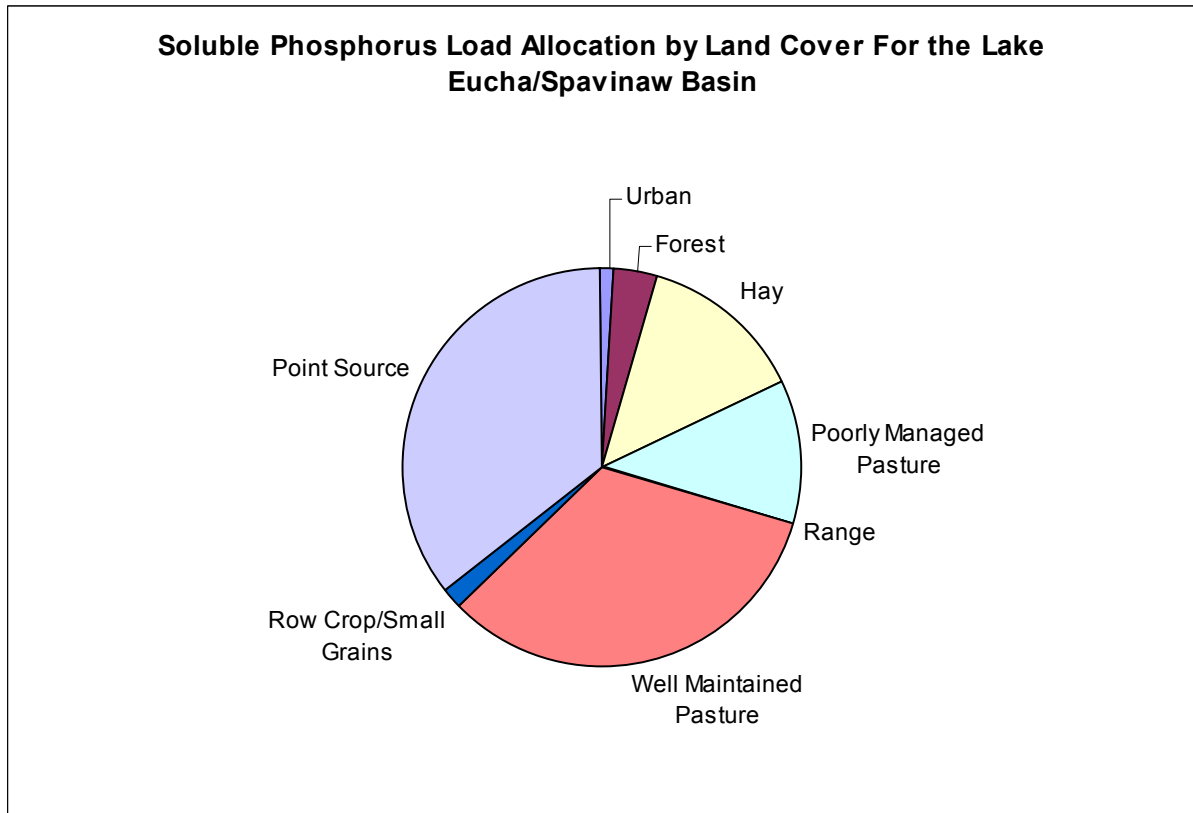
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Background conditions	11.4%	7.1%	1.4%	7.1%	5.4%	10.9%
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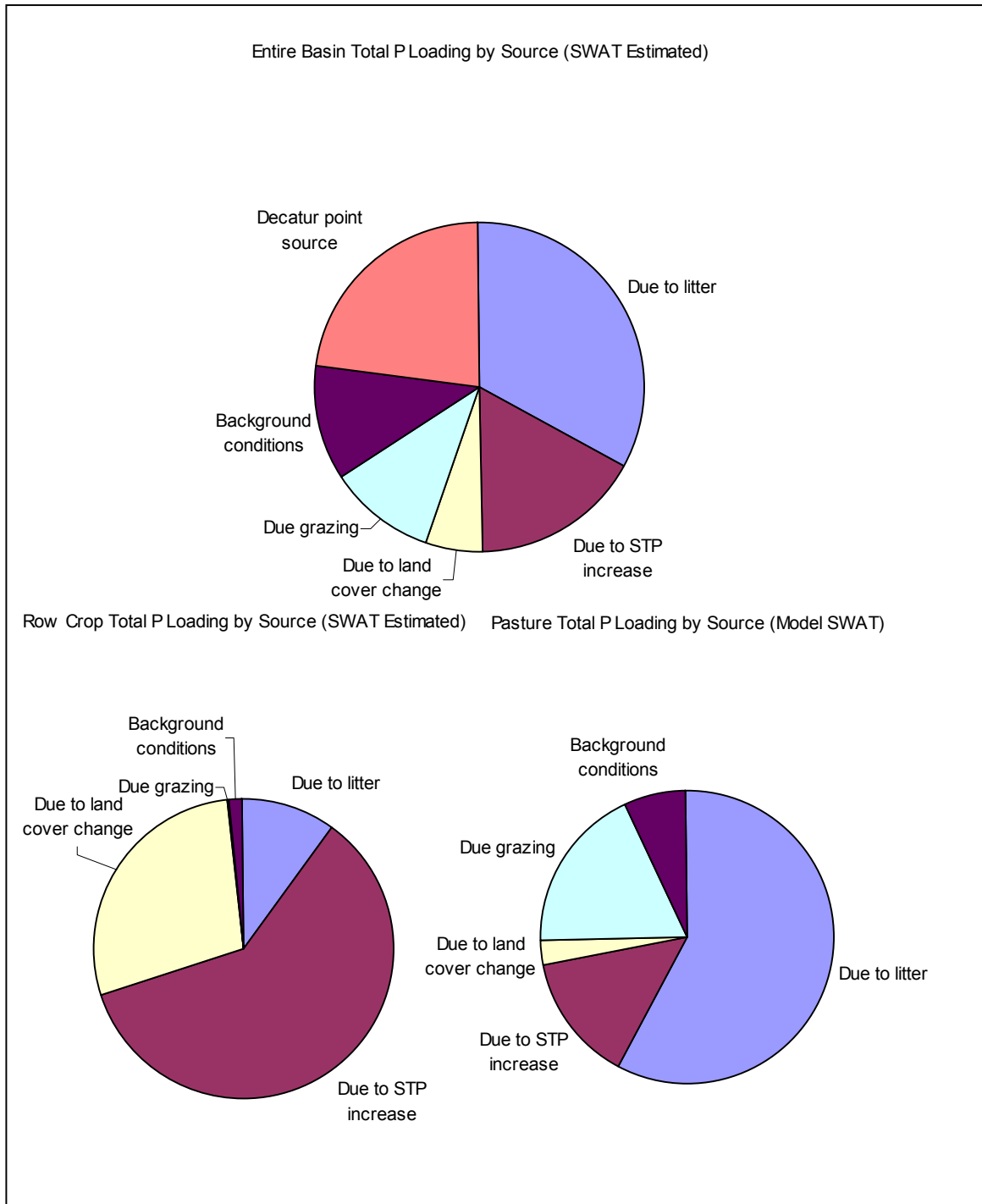




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